GDV
Unfallforschung
der Versicherer

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Analysis of accidents resulting in cyclist fatalities on rural roads

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Contents

1. Initial situation and aims

In 2023, 446 cyclists were killed in road traffic accidents in Germany, approximately 42 percent of them (189 cyclists) outside of built-up areas. Furthermore, approximately one fifth of the serious injuries suffered by cyclists were recorded outside of built-up areas (21 percent, i.e. 2,996 out of a total of 14,464 across Germany as a whole). These figures have persisted at a high level since 2018. By way of a comparison: In 2019, 445 cyclists were killed and 15,176 seriously injured on Germany's roads and both figures have since risen sharply by up to 6.5 percent [1].

In the past, only a few studies have been conducted into the safety of cyclists on rural roads outside of built-up areas. That is why the German Insurers Accident Research (UDV) undertook the study presented in summarized form here in cooperation with the "Road Traffic Planning and Road Traffic Engineering" teaching and research team at the University of Wuppertal. The aim of the study was to conduct a scientific analysis of the considerable body of information relating to the occurrence of such accidents involving cyclists on rural roads, to identify road infrastructure giving rise to conspicuously high numbers of accidents and derive recommendations for improving the safety of cyclists on these sections of the road network [2]. The central questions addressed by the study can be summarized as follows:

1. How have accidents involving cyclists on rural roads evolved during the period 2010 to 2020?

2. In what accident constellations are cyclists fatally or seriously injured and are there any particular circumstances that favour such accidents?

3. Do audits of the existing situation at road infrastructure with conspicuously high levels of accidents reveal any safety shortcomings?

4. What measures might help effectively improve the safety of cyclists on rural roads?

2. Methodological approach

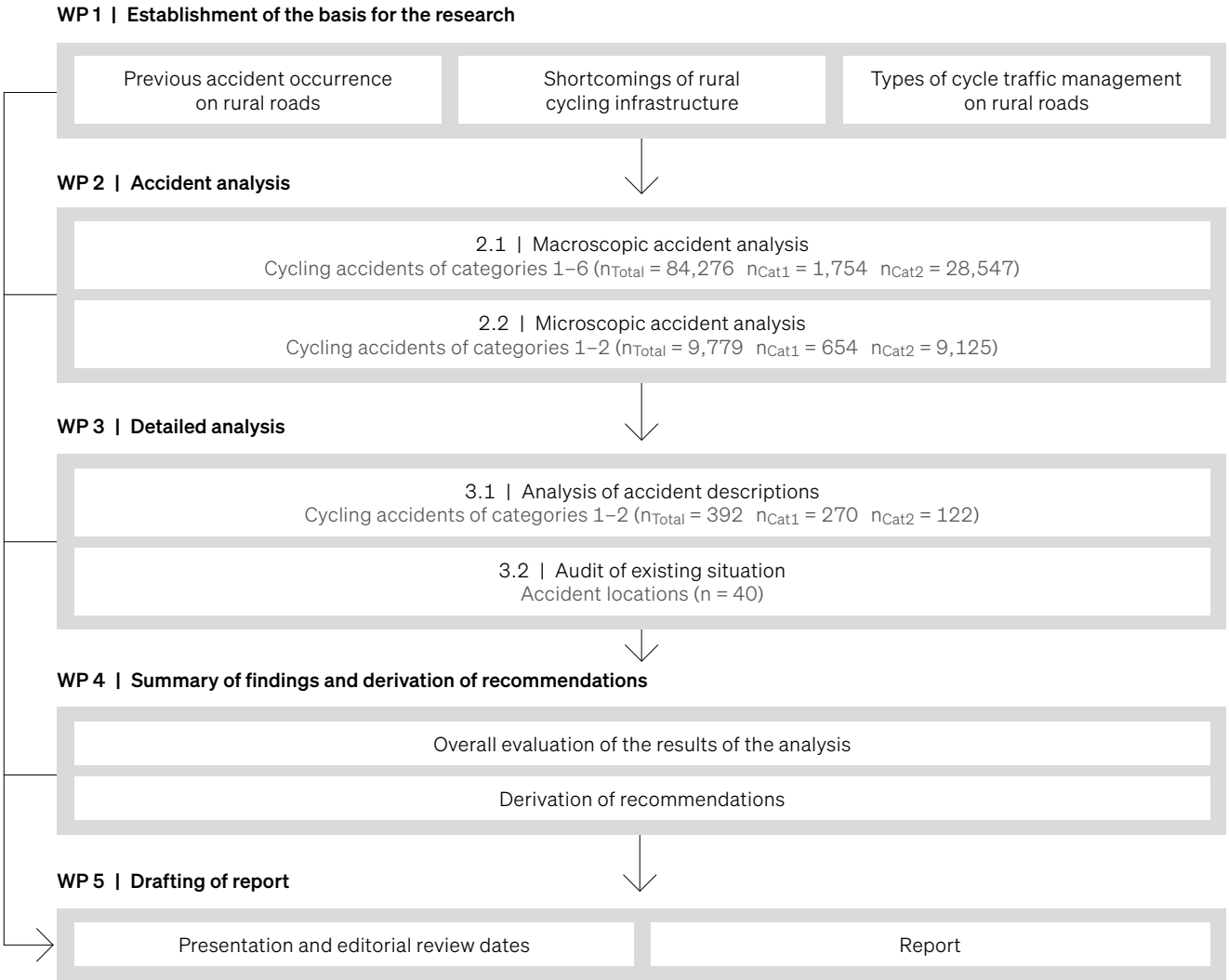
Figure 1 illustrates the methodological approach adopted during the project.

First of all, national findings on cycling accidents and the management of cycle traffic on rural roads were researched and collated. In addition, the most important guidelines and planning principles set out in the relevant regulations for the design and operation of rural roads were identified and listed (WP 1).

Accidents involving cyclists were then examined at both the macroscopic (WP 2.1) and microscopic (WP 2.2) levels. During the detailed analysis, the accident descriptions of 392 accidents resulting in fatalities or serious injuries were examined (WP 3.1) and audits of the current situation were conducted at 40 sections of road infrastructure with conspicuously high accident levels (WP 3.2) in order to identify safety shortcomings that might possibly correlate with the circumstances of the accidents.

Procedure and samples for the various stages of the analysis

Figure 1 · Methodological approach adopted during the project



3. Previous findings: Review of the literature

The available literature includes two studies by the German Federal Highway Research Institute (BASt) which have already addressed the question of the safety of cyclists on rural roads and are particularly worthy of mention. The study "Accidents on rural roads" (F1100.4208015), which was published in 2010, includes a detailed evaluation of the official accident statistics for 2007. During the study, the main characteristics of cycling accidents outside of built-up areas were identified. These were, first and foremost, turning-into/crossing accidents, driving accidents and accidents in longitudinal traffic [3].

The study "Management of cycling on rural roads" (FE 21.0055), which was published in 2020, comprised a detailed examination of cycling accidents nationwide based on accident data for the years 2008 to 2012. Among its other results, the study revealed the high level of cycling accidents among leisure cyclists. In addition, examinations conducted at intersections showed that conflicts between cyclists and motor vehicles are particularly frequent when cyclists are routed along a cycle path with right of way [4].

4. Macroscopic accident analysis

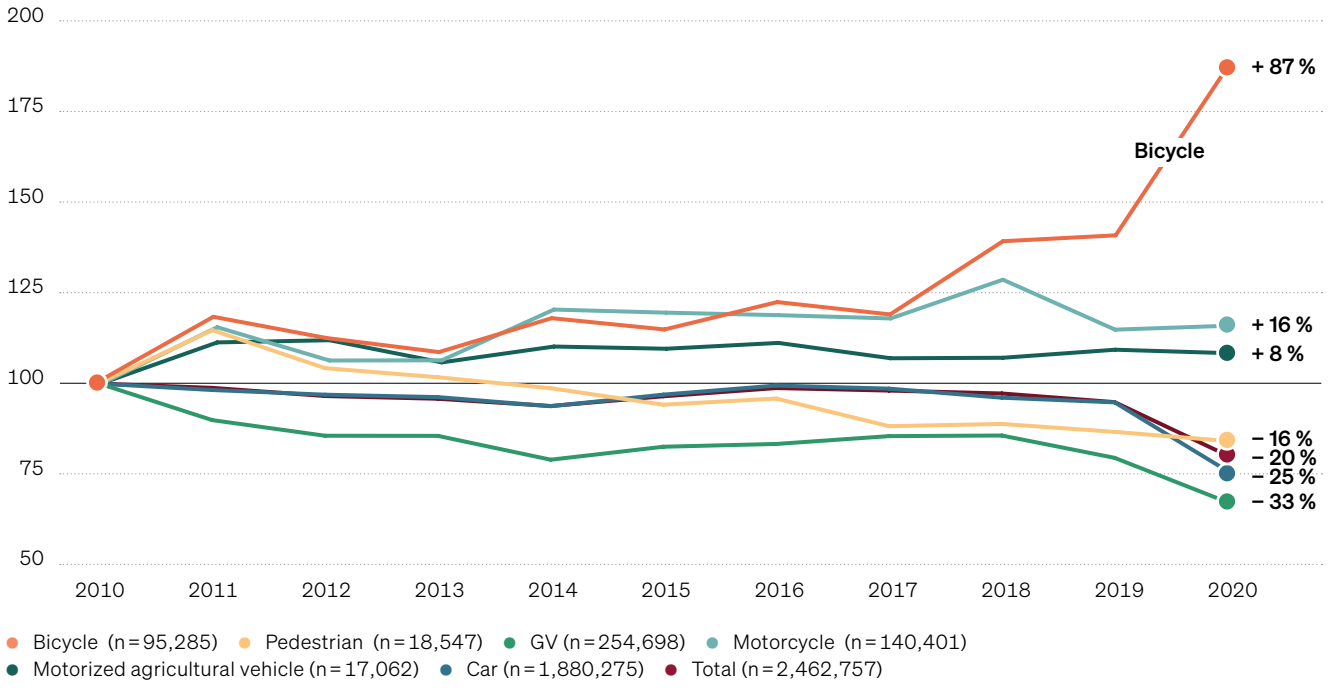
Road traffic accidents throughout Germany during the period of 2010 to 2020 were analysed as part of the macroscopic accident analysis. Since it is not possible to make any specific statements regarding cycling accidents on the basis of the published evaluations of road traffic accidents, data from the research data centres operated by the German Federal and State Statistical Offices was collected and evaluated. In this way, it was possible to conduct a separate analysis of traffic accidents on rural roads and to consider these in the context of overall accident occurrence.

An examination of the number of road users involved in accidents by type of traffic participation on rural roads as shown in Figure 2 shows that, compared to the baseline year 2010, the number of persons suffering casualties in cars fell by approximately 25 percent during the period up to 2020. The number of casualties resulting from accidents involving goods vehicles (GV) and pedestrians in rural areas also fell. By contrast, the number of persons suffering casualties while riding a bicycle increased continuously and rose sharply between the years 2019 and 2020 to register an increase of approximately 87 percent compared to 2010.

More recent data for the years 2021 and 2022 also confirms this trend. Nevertheless, the year 2021 saw the number of cyclists involved in accidents fall to 68 percent compared to the baseline year 2010. However, the corresponding number rose to 82 percent again in 2022 [5].

Dramatic increase in the number of cyclists involved in accidents on rural roads

Figure 2 · Number of persons involved in accidents (A cat. 1-6) on rural roads by type of traffic participation

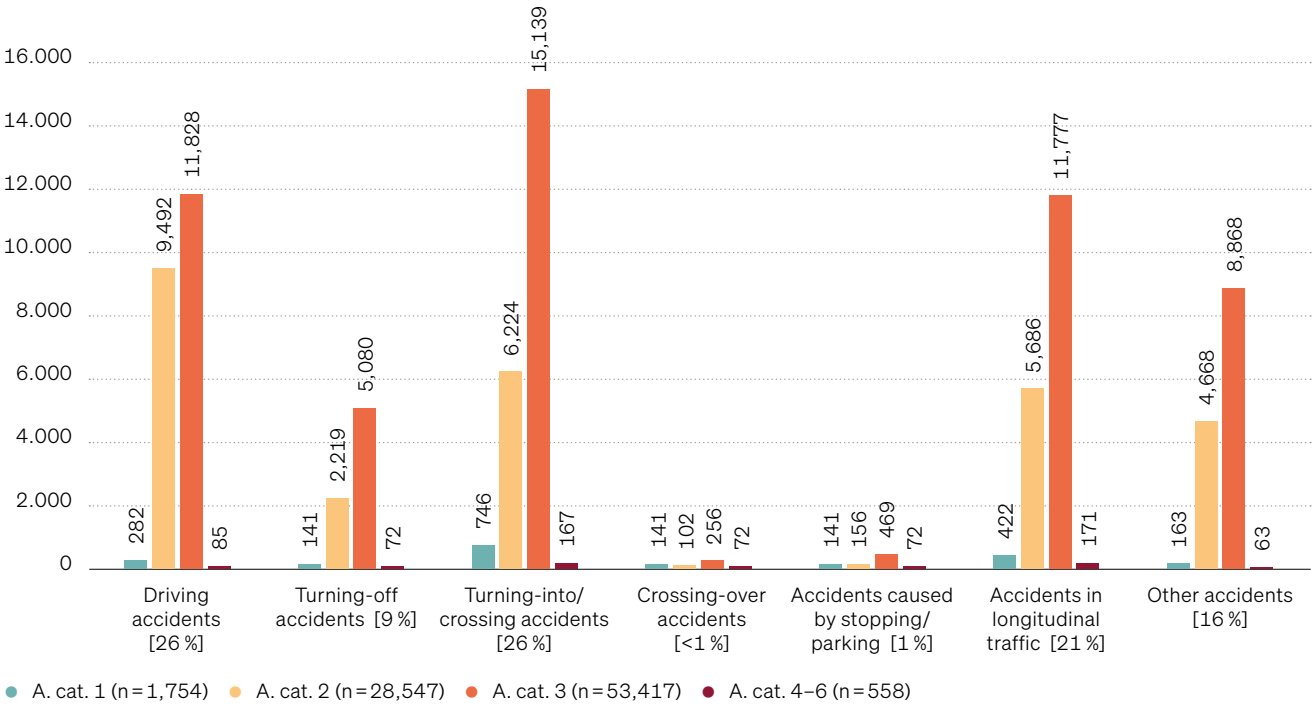


Research data centres operated by the German Federal and State Statistical Offices, microdata taken from road traffic accident statistics, 2010-2020, authors' own calculations

A comparison of the accident categories and accident types shows not only that certain accident types are more highly represented among cycling accidents on rural roads but also that certain types are more highly represented among the serious cycling accidents. Figure 3 depicts the relationship between accident category and type for cycling accidents on rural roads. It can be seen that turning-into/crossing accidents and driving accidents are the most frequently found accidents in this sample at 26 percent each. Accidents in longitudinal traffic (21 percent), other accidents (16 percent) and turning-off accidents (9 percent) are also frequent. If accident severity is also considered, the accidents involving minor injuries also mostly take the form of turning-into/crossing accidents and driving accidents. The category 2 accidents are most frequently driving accidents – here, a high level of single-vehicle accidents can be observed. By contrast, accidents with fatalities occur most frequently in turning-into/crossing situations and in longitudinal traffic (see Figure 3).

Driving accidents, turning-into/crossing accidents and accidents in longitudinal traffic account for the great majority of accidents involving cyclists

Figure 3 · Cycling accidents on rural roads – Relationship between accident category and accident type



Research data centres operated by the German Federal and State Statistical Offices, microdata taken from road traffic accident statistics, 2010-2020, authors' own calculations

5. Microscopic accident analysis

5.1 Data basis

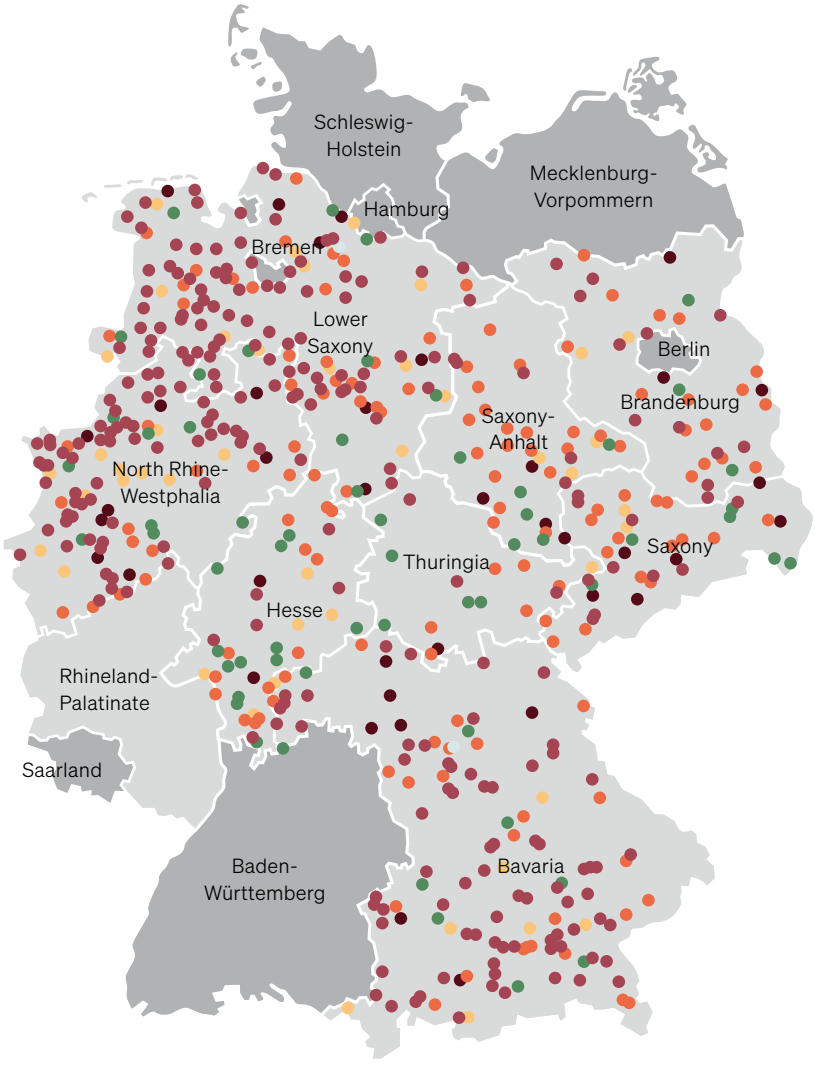
For the purposes of the microscopic accident analysis, cycling accidents resulting in fatalities or serious injuries on rural roads were evaluated for nine selected federal states for the period of 2015 to 2020. The following federal states are included in the analysis: Bavaria, Brandenburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saxony, Saxony-Anhalt and Thuringia.

Figure 4 shows the locations of the considered accidents. In addition to the non-municipal states of Bavaria and Lower Saxony, the most highly populated federal state of North Rhine-Westphalia was studied as part of the project.

The cycling accidents of categories 1 (accidents involving fatalities) and 2 (accidents involving serious injuries) include all accidents in which a cyclist was either killed or seriously injured. A distinction is also made depending on whether the cyclists were riding a traditional bicycle or a pedelec. In total, 654 accidents with fatalities (category 1) and 9,125 accidents with serious injuries (category 2) were included in the detailed analysis.

Cyclists are more often killed in turning-into/crossing accidents or accidents in longitudinal traffic

Figure 4 · Category 1 cycling accidents on rural roads in the studied federal states[1] (2015 to 2020)



1 Bavaria, Brandenburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saxony, Saxony-Anhalt and Thuringia

Accident data from Rhineland-Palatinate is not available in georeferenced form.

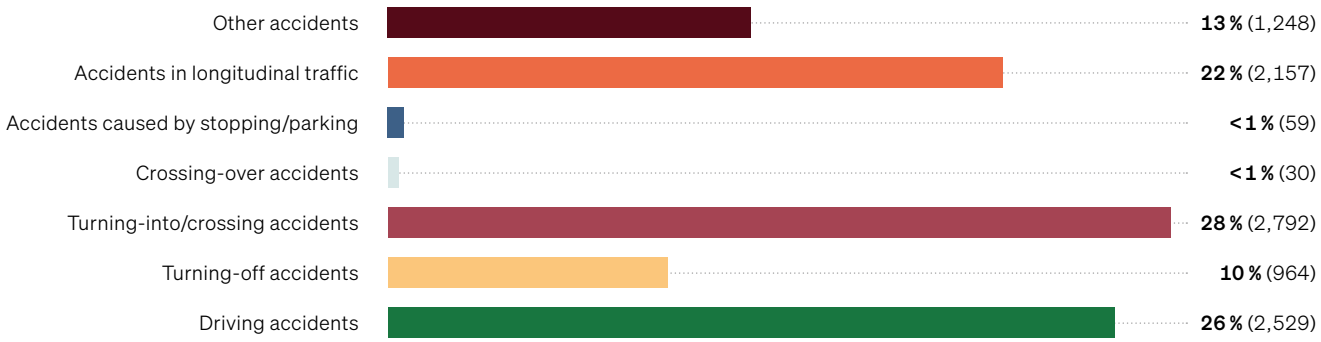
Data basis: StMB (2022), GDV (2022), LBM (2022), Straßen.NRW (2022), ZPD Polizei NDS (2021)

5.2 Accident types

An evaluation based on accident type shows that 2,790 of the accidents (28 percent) were turning-into/crossing accidents. Approximately 26 percent of the accidents were driving accidents. Accidents in longitudinal traffic accounted for 22 percent and turning-off accidents approximately 10 percent of the total. Crossing-over accidents and accidents due to stopped/parked vehicles account for only a small number of the cycle traffic accidents on rural roads. The breakdown by accident type can be seen in graphical form in Figure 5.

Turning-into/crossing accidents, driving accidents and accidents in longitudinal traffic are also responsible for the majority of cycle traffic accidents involving fatalities and serious injuries

Figure 5 · Breakdown of cycling accidents involving fatalities or serious injuries in the studied federal states by accident type; n=9,779



Data basis: StMB (2022), GDV (2022), LBM (2022), Straßen.NRW (2022), ZPD Polizei NDS (2021)

If only the accidents involving fatal injuries to cyclists are considered, then the proportion of turning-into/crossing accidents is 48 percent; driving accidents are much less frequent at 11 percent.

5.3 Parties involved and typical accident constellations

5.3.1 Total accident sample

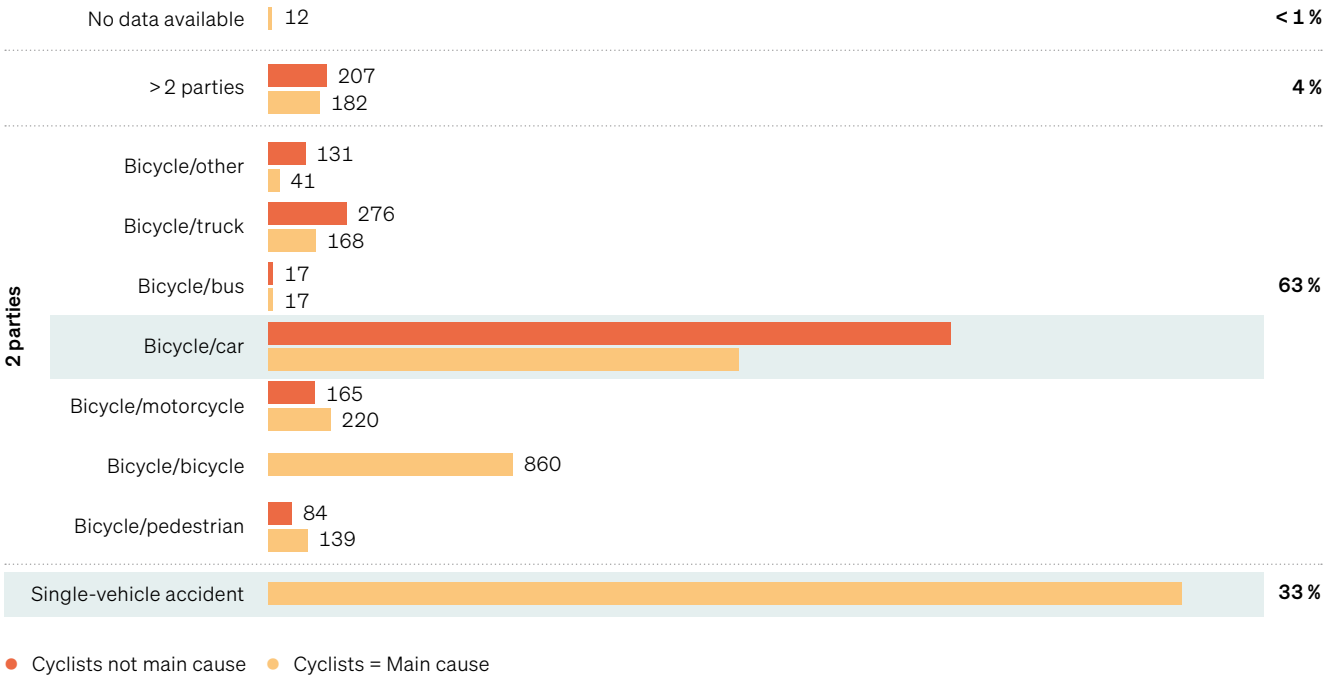
An evaluation of the number and nature of the parties involved in cycling accidents (categories 1 and 2) shows that exactly two parties are involved in approximately 63 ercent of the accidents. 33 percent of the accidents take the form of single-vehicle accidents involving only the cyclist. Relatively few of the accidents involve three or more parties. The most frequent combinations of involved parties are shown in Figure 6. It can be seen that, at approximately 42 percent, accidents between cars and cyclists are the most frequent combination – the interaction between cars and cyclists is therefore particularly important with regard to accidents in rural areas. Single-vehicle accidents are the second most frequent form of accident.

Accidents between two cyclists (9 percent) or between cyclists and motorcyclists or trucks or collisions with pedestrians are considerably less frequent. It should be noted here that these figures relate only to category 1 and 2 accidents. Figure 6 also shows the breakdown by road user causing the accident. In the majority of cases (category 1 and 2 accidents), cyclists are the primary cause of cycling accidents on rural roads. This is due, first and foremost, to the number of single-vehicle

accidents (33 percent) and accidents between multiple cyclists (9 percent). If the single-vehicle accidents and accidents between multiple cyclists are ignored and only accidents with two or more involved parties are considered, then the cyclist is the person responsible for causing the accident in less than half of the cases. There are differences depending on the constellation of parties involved: 59 percent of the accidents between cyclists and cars are caused by the car driver and 62 percent of the accidents between cyclists and trucks are caused by the truck driver. 62 percent of accidents between cyclists and pedestrians are caused by the cyclist.

Cyclists cause the majority of serious accidents themselves, except in the case of collisions with cars or trucks

Figure 6 · Structure of cycle traffic accidents involving fatalities or serious injuries on rural roads as a function of typical collision type; n=9,779



Data basis: StMB (2022), GDV (2022), LBM (2022), Straßen.NRW (2022), ZPD Polizei NDS (2021)

5.3.2 Single-vehicle accidents

Single-vehicle accidents are accidents in which no other vehicle or person apart from the cyclist is involved. Such accidents account for a third of the cycling accidents involving fatalities or serious injuries on rural roads. In 70 percent of cases, these are driving accidents, while 29 percent are recorded as “other accidents”. The main reasons for the driving accidents are: Influence of intoxicating substances, faults at the bicycle or high speeds on downhill stretches.

5.3.3 Accidents involving two parties

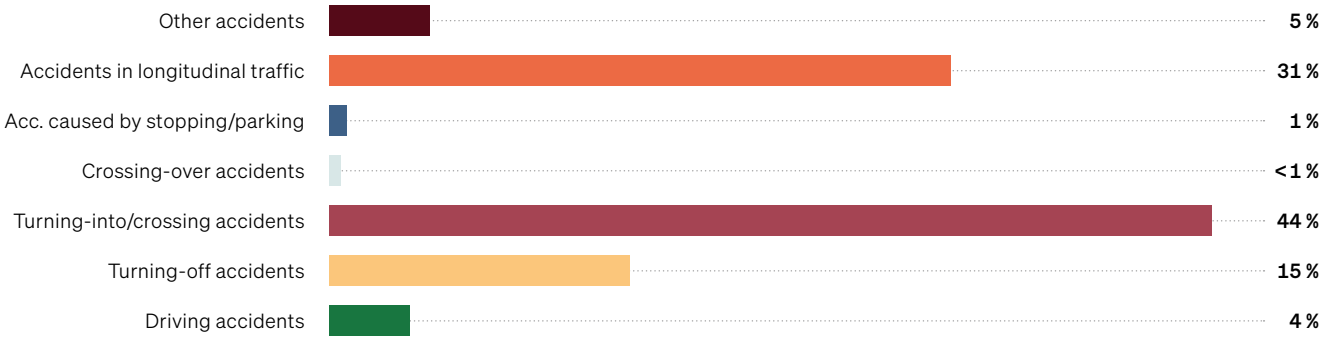
The subset of cycle traffic accidents involving exactly two parties in the nine selected federal states comprises 6,179 accidents. Cyclists were fatally injured

in 502 of these 6,179 accidents (8 percent). Within this constellation, it can again be seen that the accidents were distributed differently across the federal states. Whereas more than a hundred cyclists suffered fatal injuries in Bavaria, Lower Saxony and North Rhine-Westphalia during the six years considered here, the numbers in the other federal states – with the exception of Thuringia – were between 30 and 40 fatally injured cyclists.

Based on the breakdown by accident type of the accidents involving two parties, Figure 7 shows that approximately half of the accidents belong to the type "turning-into/crossing" (44 percent). 31 are accidents in longitudinal traffic and 15 percent are turning-off accidents. The other accident types play a less important role and account for less than 5 percent of the total.

75 percent of these collisions are turning-into/crossing accidents and accidents in longitudinal traffic

Figure 7 · Serious cycle traffic accidents on rural roads in the selected federal states as a function of accident type (2015-2020); n = 6,176



Data basis: StMB (2022), GDV (2022), LBM (2022), Straßen.NRW (2022), ZPD Polizei NDS (2021)

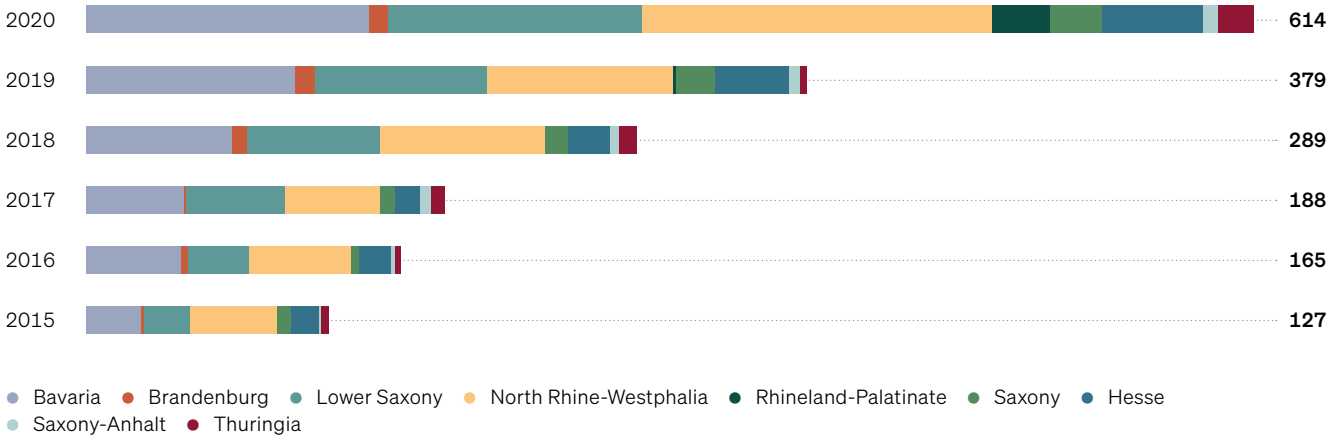
5.3.4 Pedelec accidents

Pedelec accidents account for approximately 17 percent of the serious and fatal cycle traffic accidents considered for the purposes of the microscopic accident analysis. Since 2014, they have been distinguished from S-pedelecs (coded 03) and are assigned code number 72.

Figure 8 shows the breakdown over time of Pedelec accidents between 2015 and 2020. Pedelec accidents in rural areas increased exponentially during this period. Whereas there were 127 category 1 and 2 accidents in the nine selected federal states in 2015, there were 614 pedelec accidents in 2020, that is to say about five times as many. Due to the continued growing popularity of pedelecs, this number will further increase in the coming years and account for an ever greater proportion of cycle traffic accidents. Due, in particular, to the higher speeds that can be reached using pedelecs, it is possible that the accident structure will also change (e.g. higher number of driving accidents). However, no difference between the accident structures for conventional bicycles and pedelecs can be observed in the accident sample examined here.

Pedelec accidents increased almost fivefold between 2015 and 2020

Figure 8 · Pedelec accidents on rural roads in the studied federal states (2015 to 2020); n = 1,762



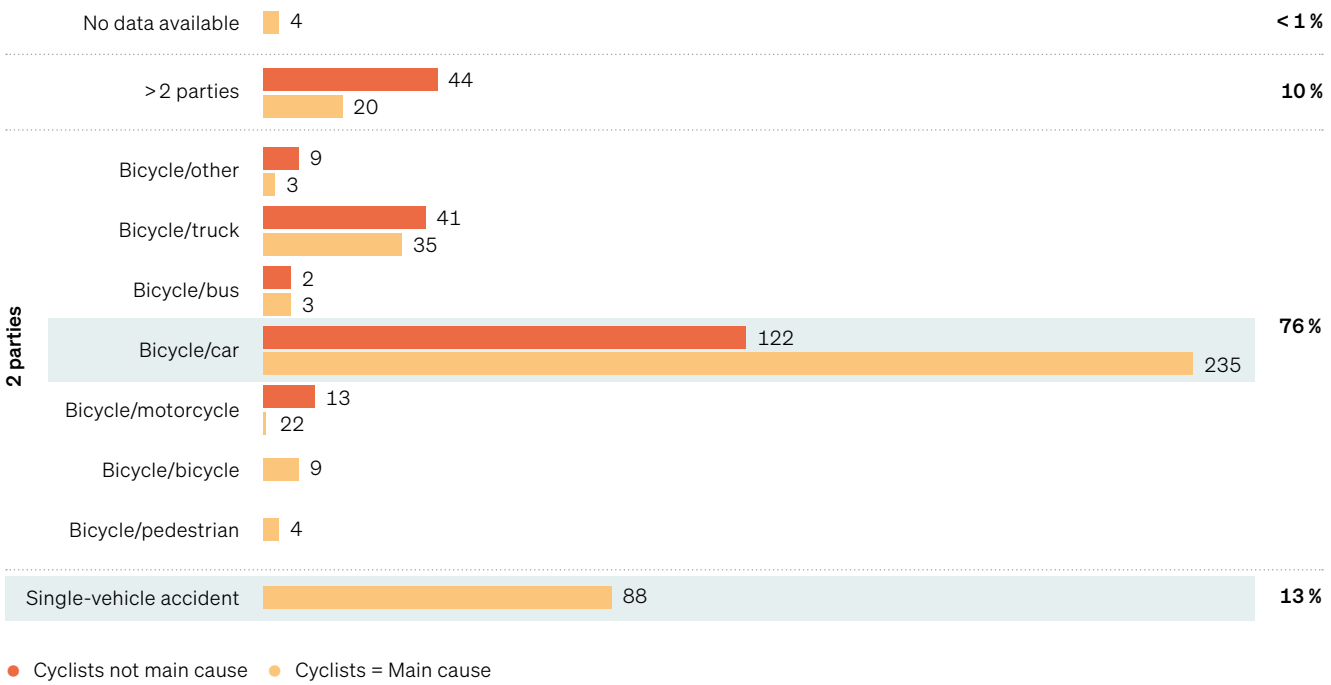
Data basis: StMB (2022), GDV (2022), LBM (2022), Straßen. NRW (2022), ZPD Polizei NDS (2021), n = 1,762

5.4 Special characteristics of accidents involving fatalities

If the accidents involving fatalities are considered separately, it can be observed that the breakdown of the parties primarily responsible for the accident is different: The majority of accidents involving two parties in which the cyclist is fatally injured are caused by the cyclist (Figure 9).

Cyclists themselves cause the majority of fatal cycle traffic accidents on rural roads; in the case of collisions with cars, they are responsible for as many as two thirds of accidents

Figure 9 · Structure of cycle traffic accidents involving fatalities on rural roads as a function of typical collision type; n=654



Datenbasis: StMB (2022), GDV (2022), LBM (2022), Straßen.NRW (2022), ZPD Polizei NDS (2021)

Cyclists are the main cause of 64 percent of the accidents (including single-vehicle accidents). If single-vehicle accidents are ignored, then cyclists are the main cause of approximately 58 percent of accidents involving fatalities. Figure 9 presents further detailed information on the number and nature of the parties involved in accidents leading to the death of a cyclist. While 13 percent of these accidents are single-vehicle accidents involving cyclists, 86 percent of them result from an interaction with at least one other road user. The road users most frequently involved in accidents with cyclists are car drivers (55 percent). Cyclists are the main cause of approximately two thirds of the accidents with this constellation. Accidents between cyclists and pedestrians and between two cyclists that result in a fatality are rare and account for approximately 2 percent of the accidents in this category. Fatal accidents between cyclists and trucks account for some 12 percent of the total.

6. Detailed analyses

6.1 Sample

A total of 392 accidents were included in the detailed analysis. Of these, 270 were accidents with fatalities and 122 accidents with serious injuries. They occurred at 322 accident sites. These sites were located in the federal states of Brandenburg, Hesse, Lower Saxony, Saxony, Saxony-Anhalt and Thuringia.

6.2 Results

6.2.1 Total accident sample

An analysis of the accident descriptions of the accidents showed that 34 of the corresponding reports contained errors. The identified errors included, for example, incorrectly coded locations and different codings for the same accident. Accidents that occurred away from roads and paths were also excluded. The descriptions of the accidents led to a further 43 accidents being categorized as individual events because these accidents were not due to infrastructural or technical defects or to personal characteristics. These accidents constitute a distinct category and were evaluated separately.

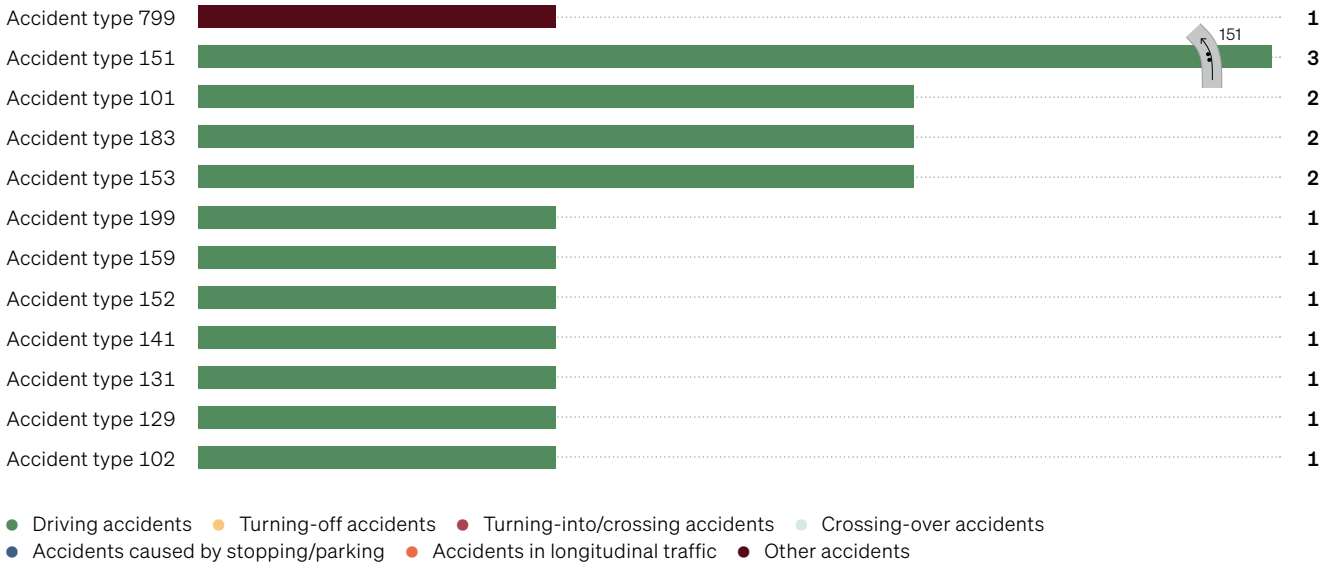
The remaining 315 accidents involving fatalities or serious injuries, 17 of which were single-vehicle accidents, were then analysed in more detail. It was possible to determine the three-digit accident type based on the written descriptions of these accidents. In only a small number of cases did these descriptions reveal other characteristics, such as the influence of alcohol or technical faults at the bicycle.

6.2.2 Single-vehicle accidents

Figure 10 shows that the single-vehicle accidents were almost exclusively driving accidents. The determined three-digit accident types show that the following infrastructural elements tend to favour the occurrence of accidents: Slopes, tight bends, uneven surfaces. 14 of the 17 single-vehicle accidents occurred on open stretches of road. What is more, 14 accidents occurred on roads not equipped with any cycling facilities.

Most single-vehicle accidents to cyclists are driving accidents occurring for various reasons (e.g., tight bends, slopes, uneven surfaces)

Figure 10 · Frequent three-digit accident types of single-vehicle accidents to cyclists; n = 17



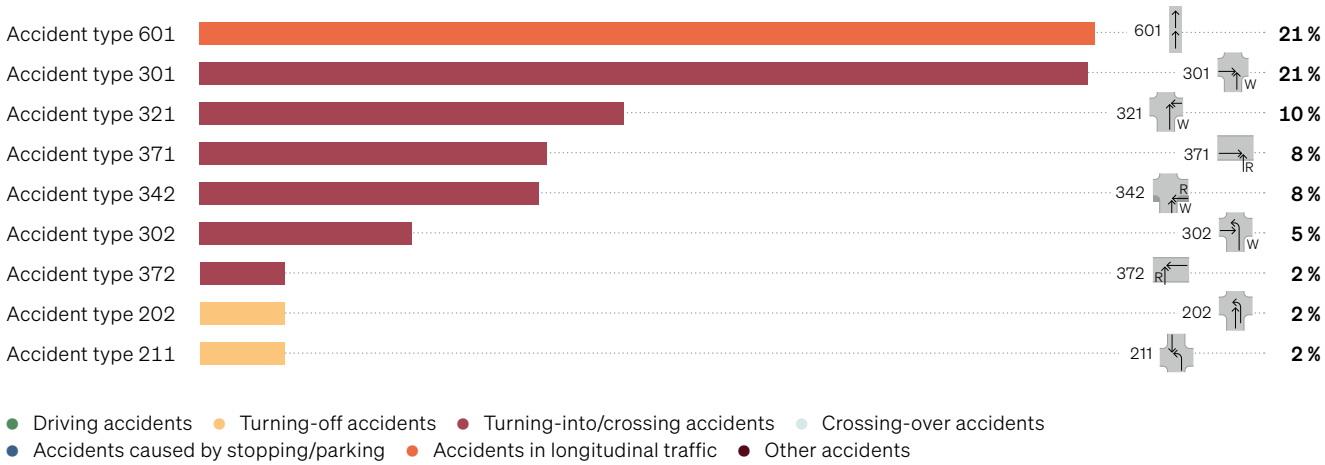
Data basis: GDV (2022), ZPD Polizei NDS (2021), n = 17

6.2.3 Accidents involving two parties

Figure 11 presents the most frequent three-digit accident types found among the 298 accidents involving at least two parties that were considered during the detailed analysis. Turning-into/crossing accidents involving cyclists occur considerably more frequently than turning-off accidents. This was also evident from the microscopic accident analysis. Within the main group of turning-into/crossing accidents, the most frequent accident type is accident type 301 (vehicle with right of way coming from the left).

Rear-impact and turning-into/crossing accidents are the most characteristic collisions involving two or more parties

Figure 11 · Frequent three-digit accident types of cycle traffic accidents involving two or more participants; n = 298



Data basis: GDV (2022), ZPD Polizei NDS (2021), n = 298

Types 321 (vehicle with right of way coming from right), 342 (vehicle with right of way coming from cycle lane on the right) and 371 (cyclist crossing/turning in) also reach noteworthy levels. In addition to the turning-into/crossing accidents, which occur primarily at intersections and/or the area in which traffic is influenced by their presence, accident type 601 (rear-end collision with vehicle in front) is also striking. This accounts for approximately 21 percent of the accidents considered in the detailed analysis of accidents involving two or more parties and predominantly occurs on stretches of open road.

6.2.4 Road infrastructure with conspicuously high cycling accident levels

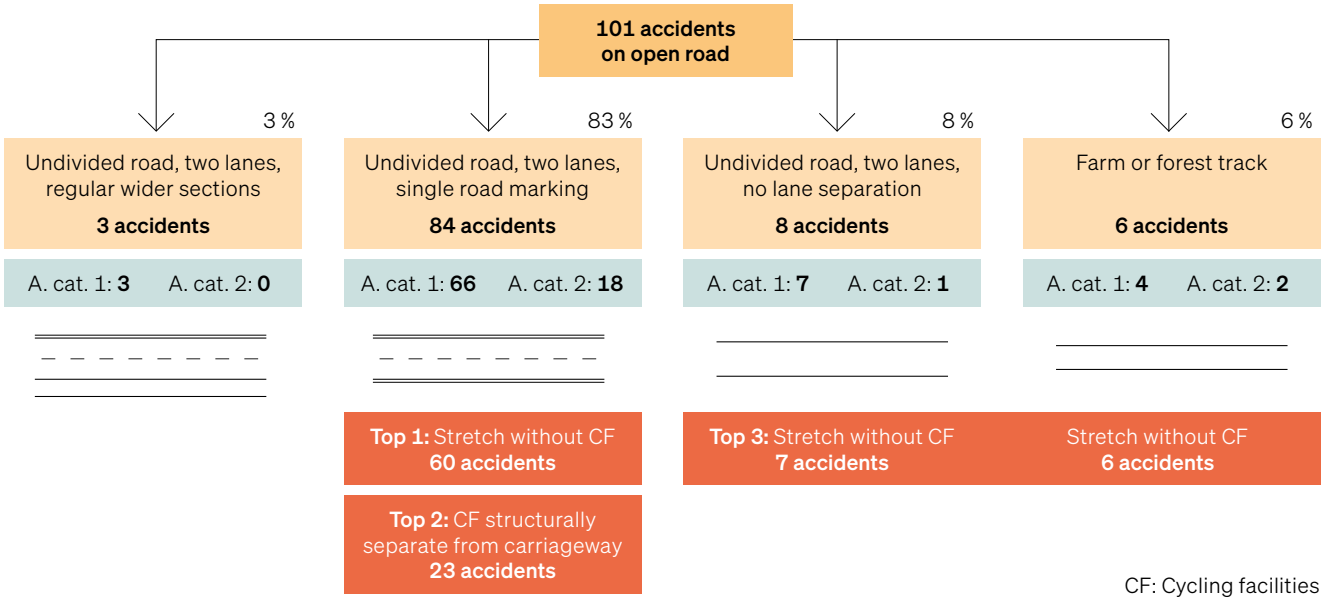
6.2.4.1 Open road

In the light of the frequent conflict situations indicated in Figures 10 and 11, the road infrastructure locations at which the accidents occurred were systematically identified on the basis of aerial photographs and data from the road information databases. Figure 12 summarizes and presents the most frequently implicated road infrastructures discussed in this subsection on cycle traffic accidents on stretches of open road.

On stretches of open road, accident type 601, in which cyclists are hit by motor vehicles coming from behind, is particularly frequent. This is particularly true of undivided two-lane rural roads with road marking but without cycling facilities, where it accounts for up to 85 percent of accidents. Other road infrastructures with conspicuously high cycling accident levels are cycling facilities that are structurally separated from the carriageway (shared paths for cyclists and pedestrians) at undivided two-lane rural roads or low-classification roads without any lane separation (central marking). It is also important to take note of the frequency of occurrence of the corresponding infrastructures in the road network.

No cycle lane was present in three quarters of the cycling accidents involving fatalities and serious injuries on stretches of open road

Figure 12 · Typical infrastructures with particularly high accident rates for category 1 and 2 cycling accidents on stretches of open road outside of built-up areas



6.2.4.2 Intersections

At intersections, there are many more collisions between cyclists and vehicles with right of way coming from the left than there are with vehicles with right of way coming from the right.

The following road infrastructures are observed particularly frequently in connection with cycling accidents at intersections outside of built-up areas (see Figure 13):

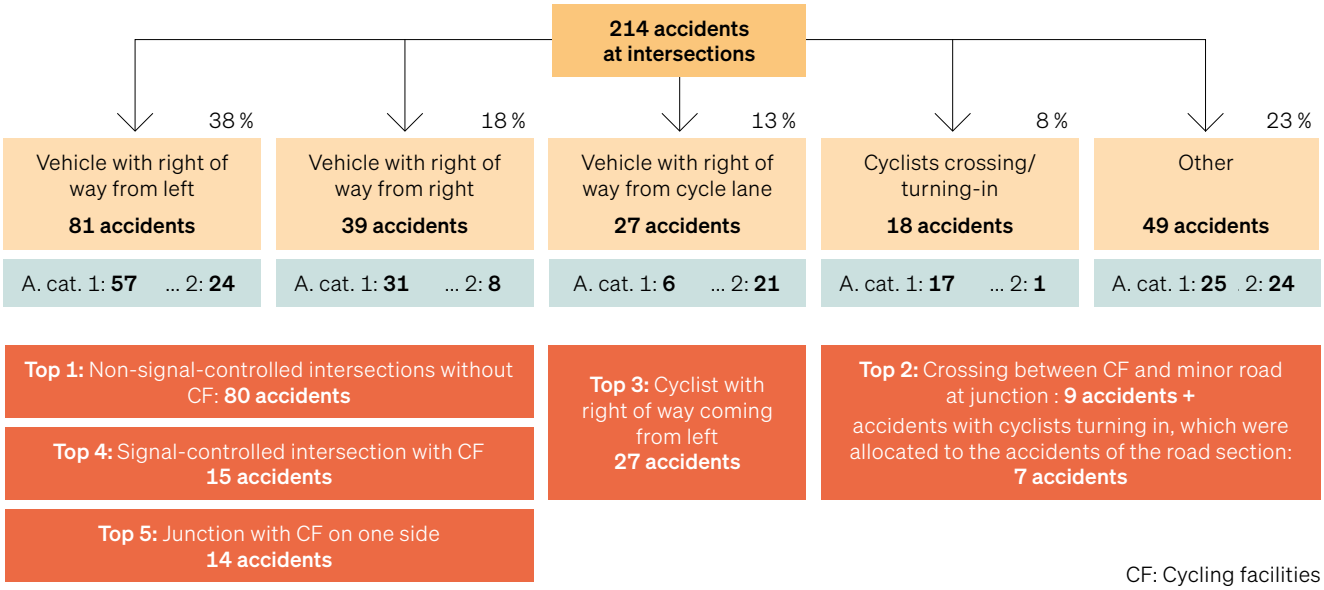
- Non traffic light-controlled intersections without cycling facilities,
- Junctions with cycling facilities opposite a minor road,
- Intersections with indicated priority and right of way for cycle traffic vis-à-vis the minor road, and
- Traffic light-controlled intersections with separate cycling facilities.

At intersections with indicated priority and right of way for cycle traffic, the greatest conflict is between motor vehicles that are turning in and cyclists that have the right of way coming from the right. In this case, it is again necessary to consider the frequency with which the various road infrastructures occur within the national road network.

Table 1 presents the typical conflicts – derived from the determined three-digit accident types – at the road infrastructures most frequently implicated in accidents at intersections.

The majority of serious cycling accidents occur at intersections without traffic lights at which there are no cycle lanes at the approaches

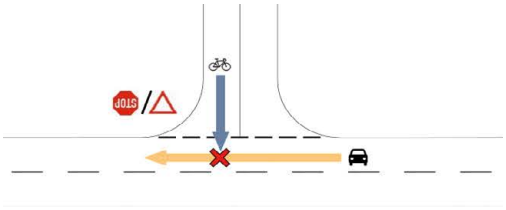
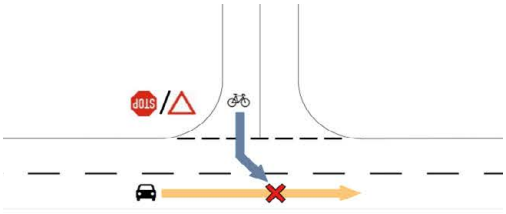
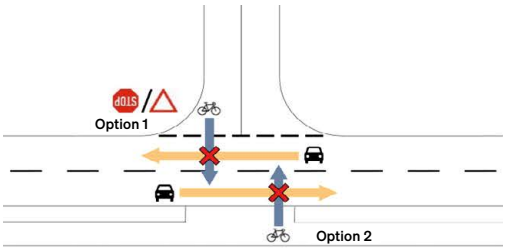
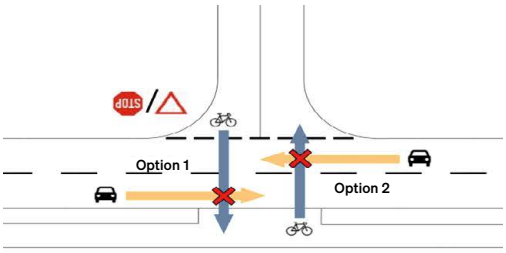
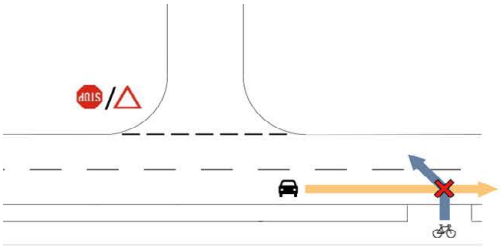
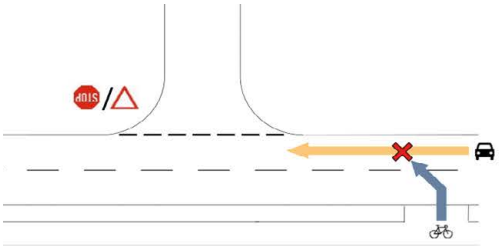
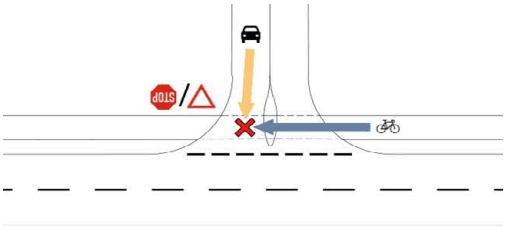
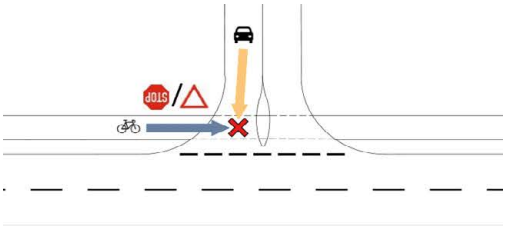
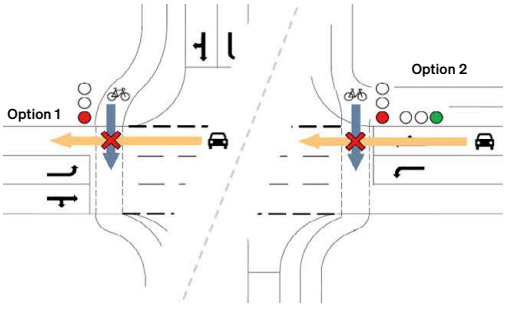
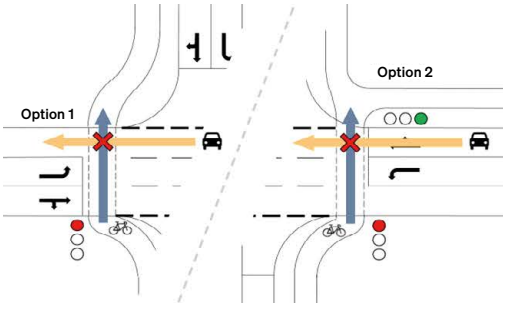
Figure 13 · Typical infrastructures with particularly high accident rates for category 1 and 2 cycling accidents at intersections outside of built-up areas



CF: Cycling facilities

Illustration of the typical conflicts that result in serious cycling accidents at intersections on rural roads

Table 1 · Typical conflicts involved in cycling accidents (A. cat. 1, 2) at intersections with particularly high accident levels outside of built-up areas.

	Bicycle ● Motor vehicle	Bicycle ● Motor vehicle
Non traffic light-controlled intersections without cycling facilities		
	Vehicle with right of way from left	Vehicle with right of way from right
Junction with cycling facilities on one side		
	Vehicle with right of way from left	Vehicle with right of way from right
		
	Vehicle with right of way from left	Vehicle with right of way from right
Cycling facilities with right of way vis-à-vis the minor road		
	Cyclist(s) with right of way from left	Cyclist(s) with right of way from right
Signal-controlled intersections with cycling facilities		
	Vehicle with right of way from left	Vehicle with right of way from right

Data basis: 214 accidents included in the detailed analysis

7. Findings of audits of current situation

7.1 Selection of locations

The selection of the locations was based on the frequently occurring three-digit accident types observed in the detailed analysis. These account for 212 of the total of 315 accidents included in the detailed analysis, i.e. 67 percent. They comprise 60 typical accidents on the open road and 152 typical accidents at intersections. The 212 accidents occurred at 179 different accident locations.

At 26 of the 179 locations, there were at least three accidents with fatalities or serious injuries during the period 2019 to 2021 (Destatis German Accident Atlas). There were also another 14 locations in the surrounding road network with a lower accident occurrence at which typical serious and fatal cycling accidents had occurred. It was therefore possible to audit all the locations with conspicuously high levels of accidents at intersections (Table 1) and on stretches of open road.

7.2 Shortcomings

A total of 40 of the locations were audited. During the audits, particular emphasis was placed on the cyclist's perspective in order to focus on the shortcomings that might jeopardize the safety of cyclists at these locations. The current lists of shortcomings recorded by the German Federal Highway Research Institute (BASt) (version: June 2023) [13] were used to provide support during the audits. Accident occurrence over the last six years together with the associated accident descriptions were considered in combination with the results of the detailed analysis at the 40 selected locations. All the shortcomings were recorded, even if they were not mentioned in the BASt's current lists of shortcomings.

High motor vehicle speeds and insufficient sight distances and/or restricted visibility are the most frequently identified shortcomings

Table 2 · Frequently identified shortcomings

Group	Shortcoming	Comparable shortcoming in list of shortcomings	Number of locations (N=40)
Road alignment	High motor vehicle speeds	-	22
Visibility at intersection	Restricted visibility when turning in	Field of view/sight triangles not respected	21
Cross-sections	High motor traffic volumes (longitudinal or crossing traffic)	Specific characteristics of traffic make-up not taken into account	15
Design of intersection	Intersection not recognizable in good time	Intersection not recognizable in good time	13
Design of intersection	Large turning-in/turning-off radii	Radius too large	9
Ease of recognition (visibility)	Shadows cast by trees	Influence of lighting conditions	8

Table 2 shows the shortcomings most frequently revealed by the audits. High motor vehicle speeds were observed at a total of 22 of the 40 locations and were categorized as being conducive to accidents. In some cases, this was because the speed limits were set too high or because they were regularly exceeded. This

results in large speed differences between motor vehicles and the cyclists using the carriageway that may then result in critical conflict situations or accidents. This shortcoming is not reflected in the BASt's list of shortcomings (section on rural roads – audit of current situation) [13].

Another frequently observed shortcoming is restricted visibility when turning-in (at a total of 21 locations). This shortcoming is already entered in the list of shortcomings. At 15 of the 40 locations, high motor traffic volumes were observed on the main or minor road and this, in combination with the design of the infrastructure, was considered to represent a safety risk for cyclists.

7.2.1 Example: Open road

Table 3 presents an audited section of open road at which a fatal accident occurred. It is an undivided two-lane rural road without cycling facilities on which cyclists ride in mixed traffic. The speed limit is 100 km/h. The audit revealed the following

Fatal cycling accident at speed of 100, high motor traffic volume and no cycle lane

Table 3 · Audit of current situation – Open road (example of a rural road)

Structural and traffic-related characteristics

Intersection with defined right of way – Z. 205
Speed limit on main road: 100 km/h
AADT: approx. 7,000 motor vehicles/24h
Carriageway width: 8.50 m
Road widened in area of intersection, lane width: 3.35 m

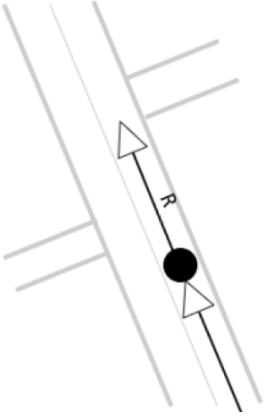
Location

Accident occurrence 2017–2022

	A(D)	A(I)	A(SI)
Total	0	1	1
Cycle traffic accidents	0	1	1

$AC_{aA(I,D)}$ = 210,655 Euro/yr
$AC_{A(I,D)/A}$ = 1,263,931 Euro/A

Cycle traffic accident diagram



shortcomings: high motor traffic volume, high motor vehicle speeds, overtaking, staggered crossing of main road by cyclists, intersections difficult to recognize, restricted visibility on the approach.

7.2.2 Example: Intersections

Table 4 shows an example of an audited intersection. It is a junction with controlled right of way at which cyclists have priority vis-à-vis the secondary arm of the intersection. This intersection had been the scene of 14 turning-into/crossing accidents between motor vehicles required to wait and cyclists with right of way. In this example the conflict between motor vehicles turning in from the right and cyclists arriving from the right is particularly noticeable. During the audit, the excessive width of the junction and the high motor traffic volume on the secondary arm of the intersection (motorway junction) were identified as shortcomings.

Accident black spot where many cyclists have been seriously injured at a junction where cyclists have right of way

Table 4 · Audit of current situation – Intersection where cyclists have right of way (example)

Structural and traffic-related characteristics

Intersection with defined right of way – Z. 205
Speed limit on main road: 70 km/h
Width of cycle crossing: 2.00 m
Cycle crossing set back by: 1.30 m
Island set back by: 3.90 m

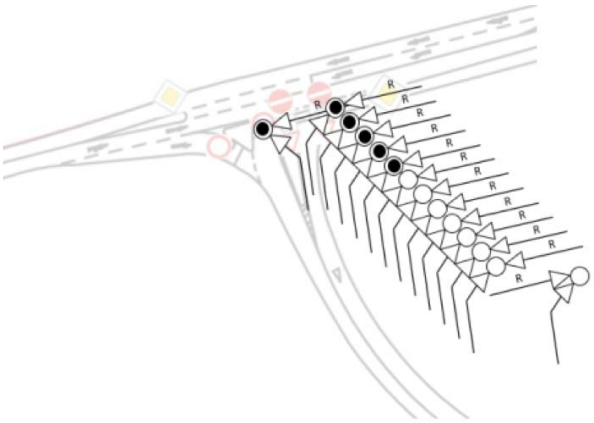
Location

Accident occurrence 2017–2022

	A(D)	A(I)	A(SI)
Total	0	18	6
Cycle traffic accidents	0	14	6

$AC_{aA(I,D)}$ = 184,655 Euro/yr
$AC_{A(I,D)/A}$ = 61,552 Euro/A

Cycle traffic accident diagram



8. Recommendations for improving traffic safety

The results of the research project give rise to the following recommendations.

8.1 Open road

Accidents in longitudinal traffic and driving accidents are both strikingly frequent and typical on open stretches of road. However, given that there are differences between the locations at which these two types of accident occur, it is necessary to implement different measures to improve the safety of cyclists.

When cycling is permitted on undivided two-lane rural roads, separate cycling facilities should always be provided in order to prevent, in particular, the typical rear-impact collisions that occur between motor vehicles and cyclists. If this is not possible, the speed limit on these stretches of road should be reduced to a level appropriate to the prevailing situation in order to prevent excessively high speed differences between car drivers and cyclists and make it possible to cycle in safety.

At locations where cyclists are responsible for driving accidents, the necessary uninterrupted sight distances should be ensured – for example, by regularly cutting back the greenery at the side of the road. In addition, signs should be present to indicate danger points, e.g. at tight curves or steep slopes, so that cyclists can adapt to ride appropriately in good time. The same applies when the cycling facilities are structurally separated from the carriageway.

8.2 Intersections

Recommendations for intersections and/or approaches with defined right of way and where cyclists use the carriageway (no cycling facilities present in the area of the intersection) and which are characterized by particularly high levels of accidents:

- Eliminate obstacles to visibility for all traffic streams (e.g. by regularly cutting back greenery and trees),
- Prevent the parallel positioning of two vehicles in the minor road access point through appropriate structural measures or markings,
- Clearly indicate the obligation to wait at the intersection,
- Reduce the speed limit on the main road,
- Traffic-dependent traffic lights

Recommendations for junctions with cycling facilities located opposite the minor road:

- Eliminate obstacles to improve visibility during the approach to the junction (e.g. by regularly cutting back greenery and trees),

- Enable safe crossing for cyclists between cycling facility and minor road (e.g. by interrupting the side separating strip and installing an on-demand traffic light system),
- Reduce the speed limit on the main road.

Recommendations for intersections at which the cycle traffic along the main road passes along a cycling facility and has a right of way vis-à-vis the secondary approach to the intersection:

- Prevent the parallel positioning of two vehicles in the minor road approach to the intersection through appropriate structural measures or markings,
- Eliminate obstacles to visibility (e.g. by regularly cutting back trees and greenery),
- On-demand traffic light system for safe crossing by cyclists or introduce an obligation for cyclists to wait.

Traffic light-controlled intersections with separate cycling facilities were also found to be highly prone to serious and fatal cycling accidents on roads outside of built-up areas. The great majority of these accidents resulted from red-light violations (in 14 of the 15 cycling accidents at intersections with traffic lights examined as part of the detailed analysis) by cyclists, which very often resulted in their death. Recommendations for improving safety:

- Shorter red-light phases and therefore shorter waiting times for cycle traffic (e.g. through traffic-dependent control),
- Green phase to allow cyclists to cross the entire cross-section
- Cyclist detection systems ahead of the intersection in order to reduce waiting times for cyclists and consequently increase their acceptance of the traffic lights.

8.3 Further recommendations

Targeted campaigns should be conducted to raise cyclists' awareness of the need to ride safely on rural roads. This is particularly important in the case of older road users because these users are disproportionately subject to serious or fatal injuries. Suitable cycling training could therefore additionally help older persons to ride safely.

The widespread use of in-vehicle driver assistance systems that warn of collisions with cyclists or actively prevent these even at high speeds should be encouraged.

The conducted audits of the current situation also show that potential shortcomings that are of relevance for cyclists should be given more prominence in the lists of shortcomings made available by the German Federal Highway Research Institute. A recommendation concerning the shortcomings that should be added is presented in the research report for the current study.

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